DARPA Prognosis
Bidder's Conference

September 25-26, 2002

Progress in Thermosonic Crack Detection for Nondestructive Evaluation

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ACKNOWLEDGMENTS: The work described in this presentation was sponsored in part by the DOT/FAA William J. Hughes Technical Center's Airworthiness Assurance Center of Excellence (AACE), under Contract Number DTFA0398D-00008, Award Number DTFA0300PIA037, in part by the U.S. Navy, NSWC, under P.O. Number N00167-00-M0498, by the Office of Naval Research under Award Number N00014-02-1-0259, in part by Universal Technology Corporation, under Contract Number F33615-97-D-5271, Task Order 0002-030, Subcontract Agreement 01-S437-002-30-C1, in part by SAIC under Subcontract Number 4400056105, and in part by the Institute for Manufacturing Research, Wayne State University.

U.S. Patent No. 6,236,049, May 22, 2001

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Principle of Thermosonic Imaging

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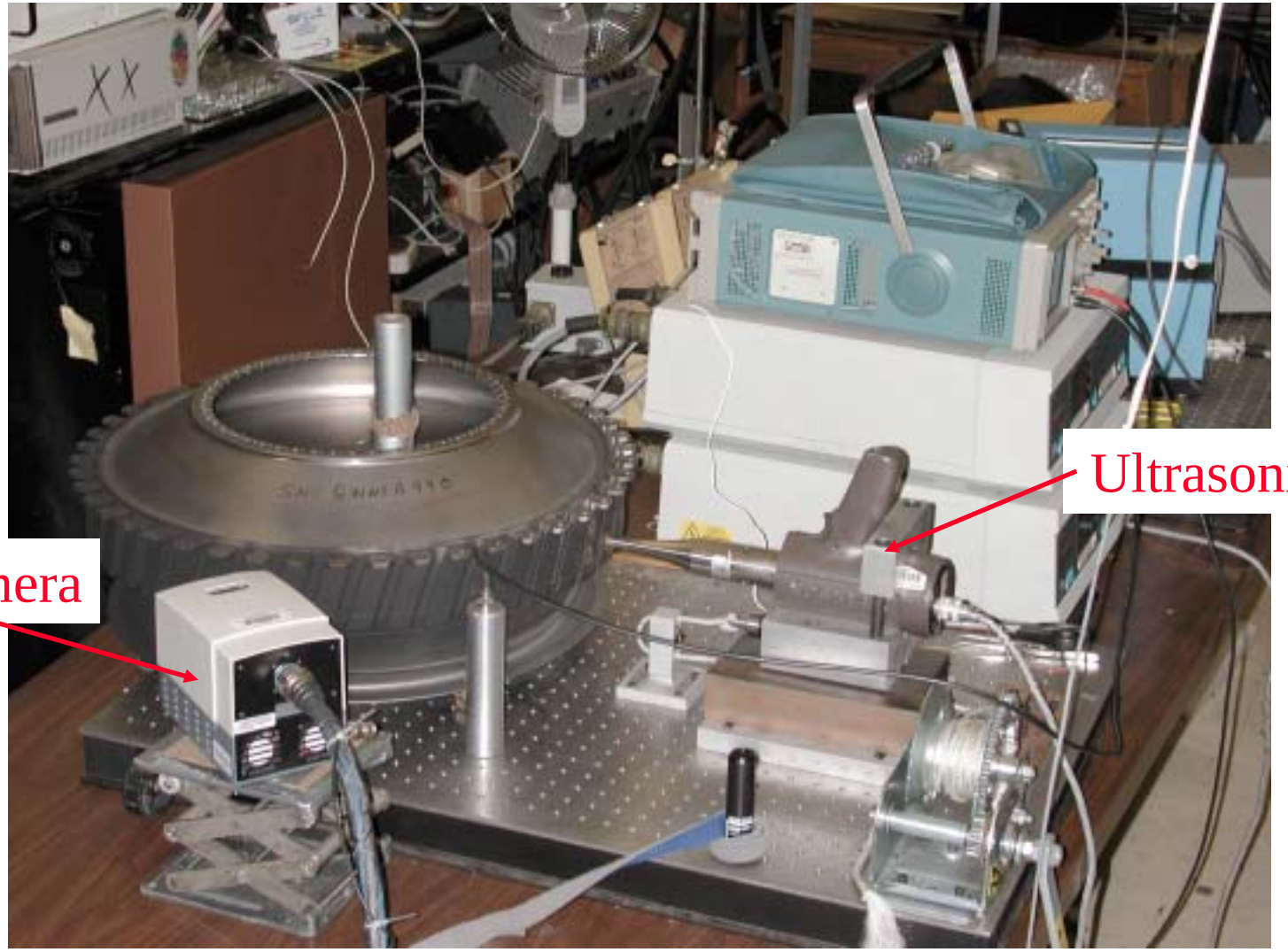
Experimental Arrangement



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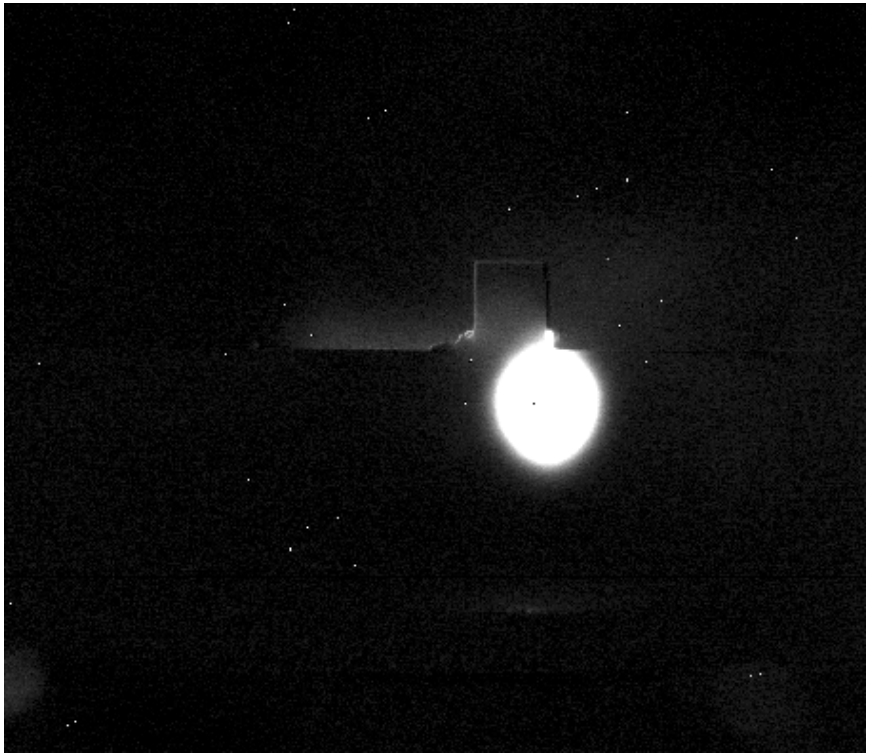
40kHztang3lock.avi

Thermosonic Detection of a crack in a simulated "anti-rotation tang"



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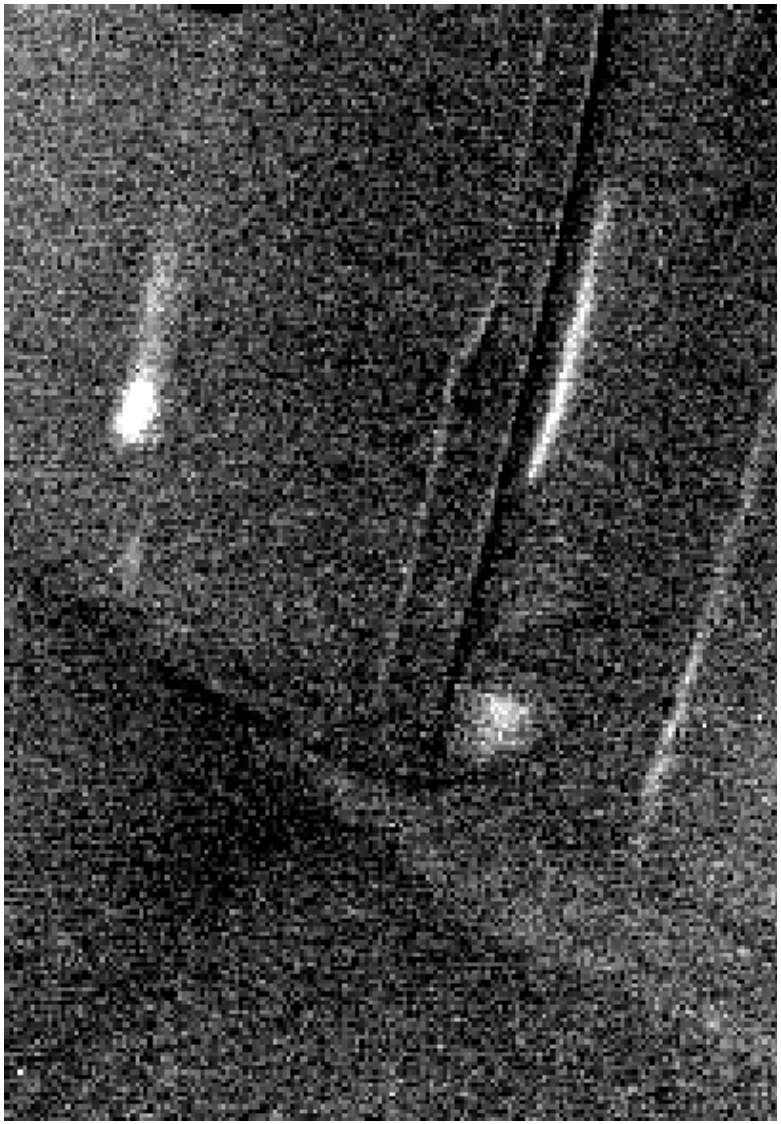
Cracks in Two Adjacent Slots in a F-110 Fan Disc



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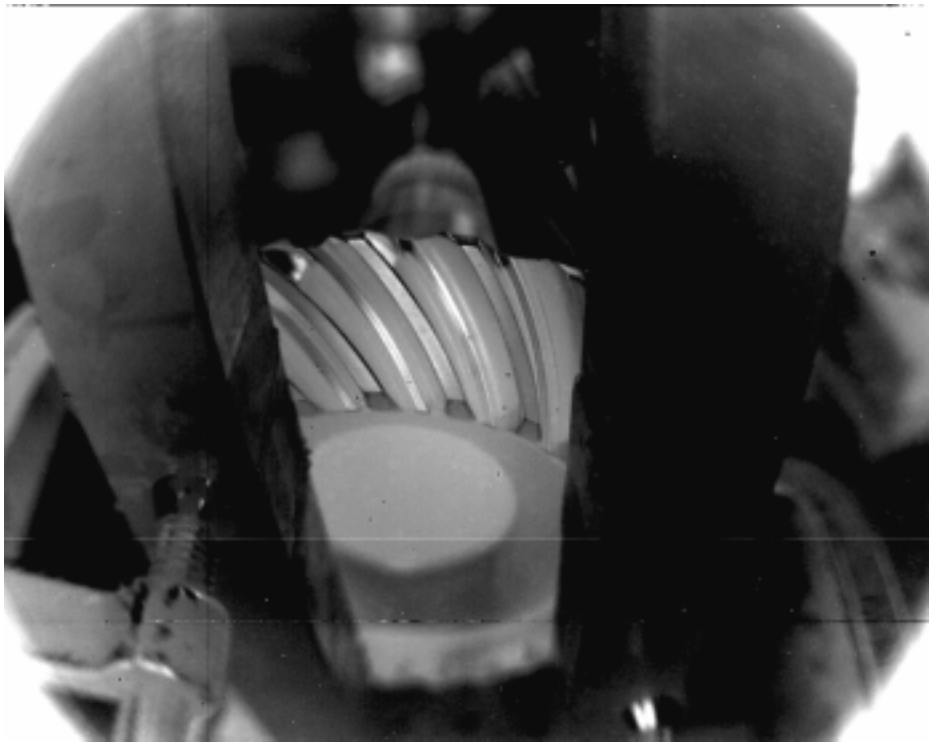
Navy_gearC2.avi

Navy_gearC1.avi

Thermosonic Detection of a subsurface crack in a bevel gear from a helicopter

William J. Hardman (NAVAIR)



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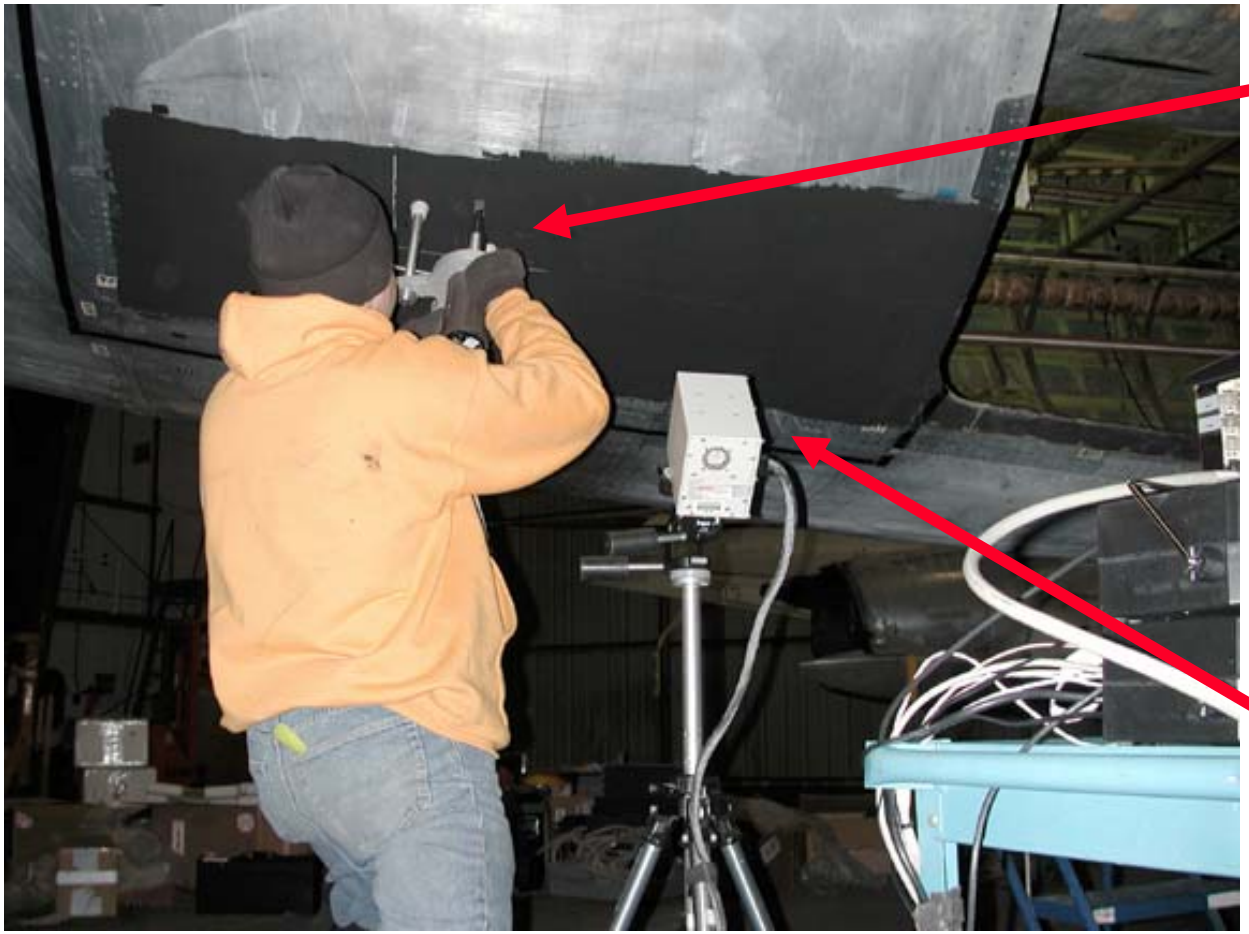
Hand-held ultrasonic source with *"Tripod" design*

Inspecting for cracks and corrosion near rear cargo door of B737 Testbed at AANC



Ultrasonic Source

Hand-held ultrasonic source with Tripod design

IR Camera for wide-area inspection

PORTABLE SYSTEM FOR ON-AIRCRAFT FIELD INSPECTIONS

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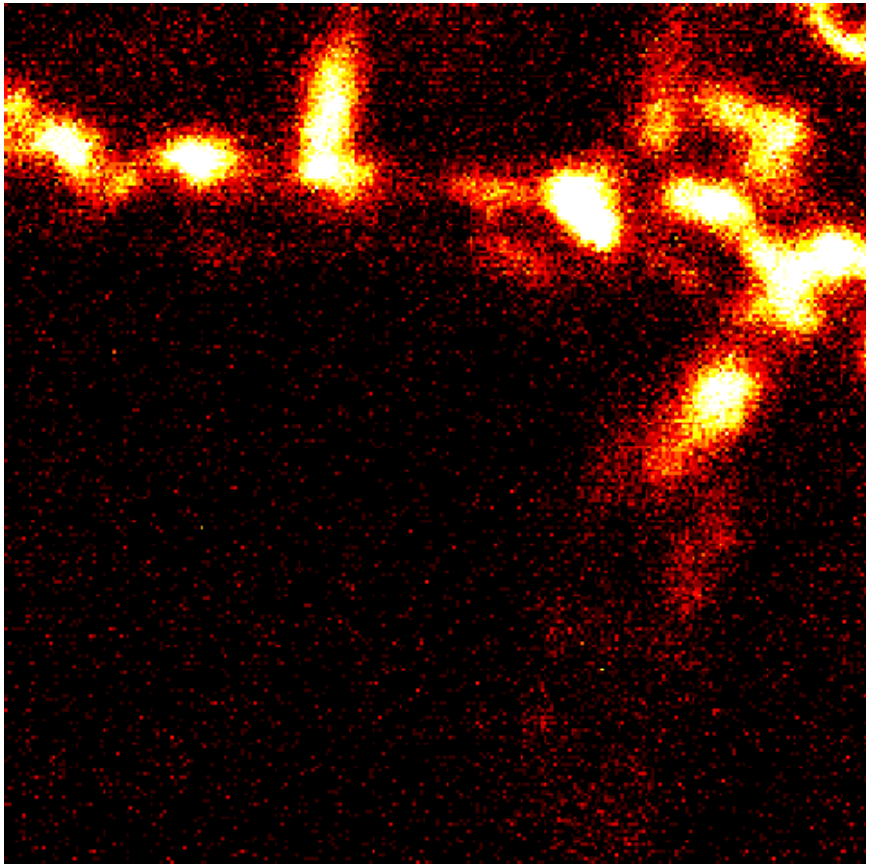
737carocrssion1s.avi

Corrosion Near Rear Cargo Door of B737 Testbed at AANC



Hidden corrosion also can be detected by thermosonics

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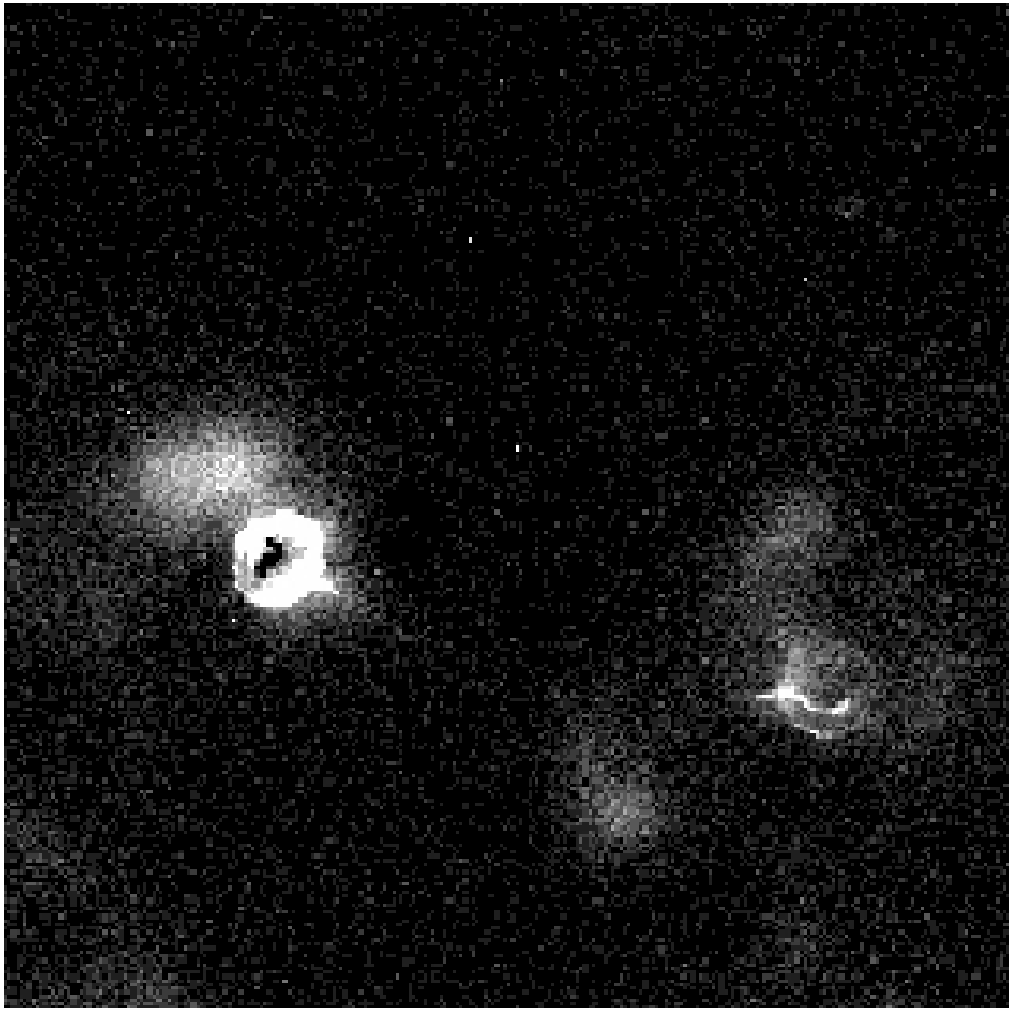
Two Adjacent Fasteners with Cracks Caused by Corrosion Near Rear Cargo Door of B737 at AANC



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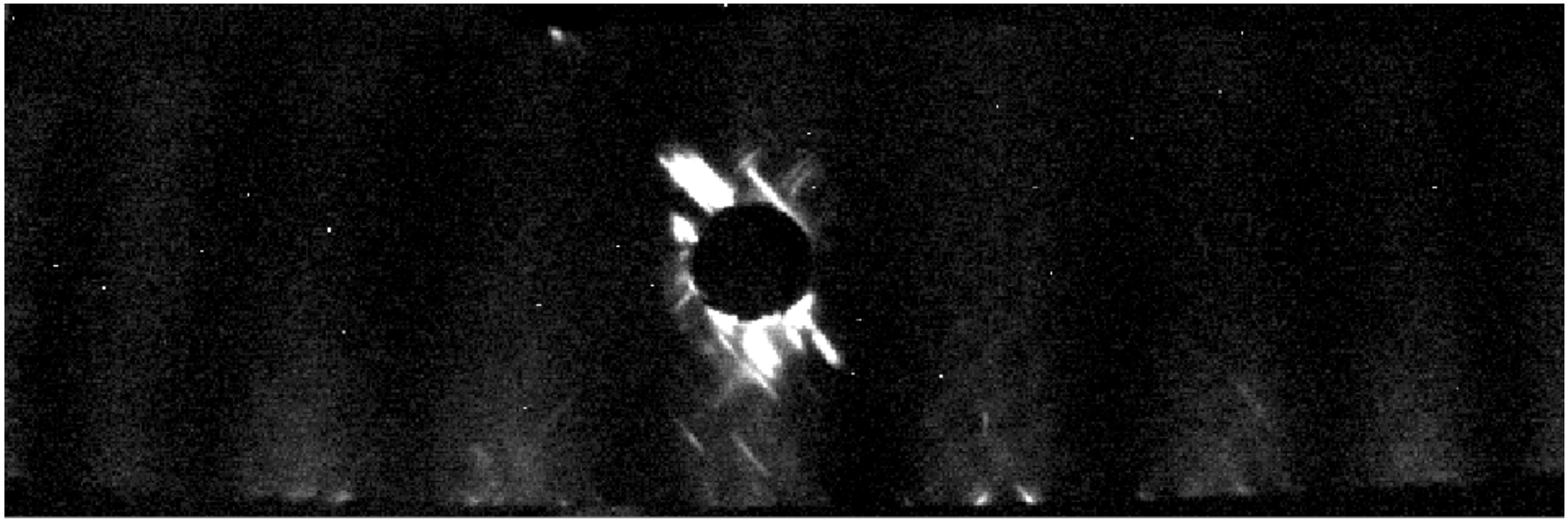
Graphite Fiber Reinforced Composite Fatigue Specimen with Center Hole



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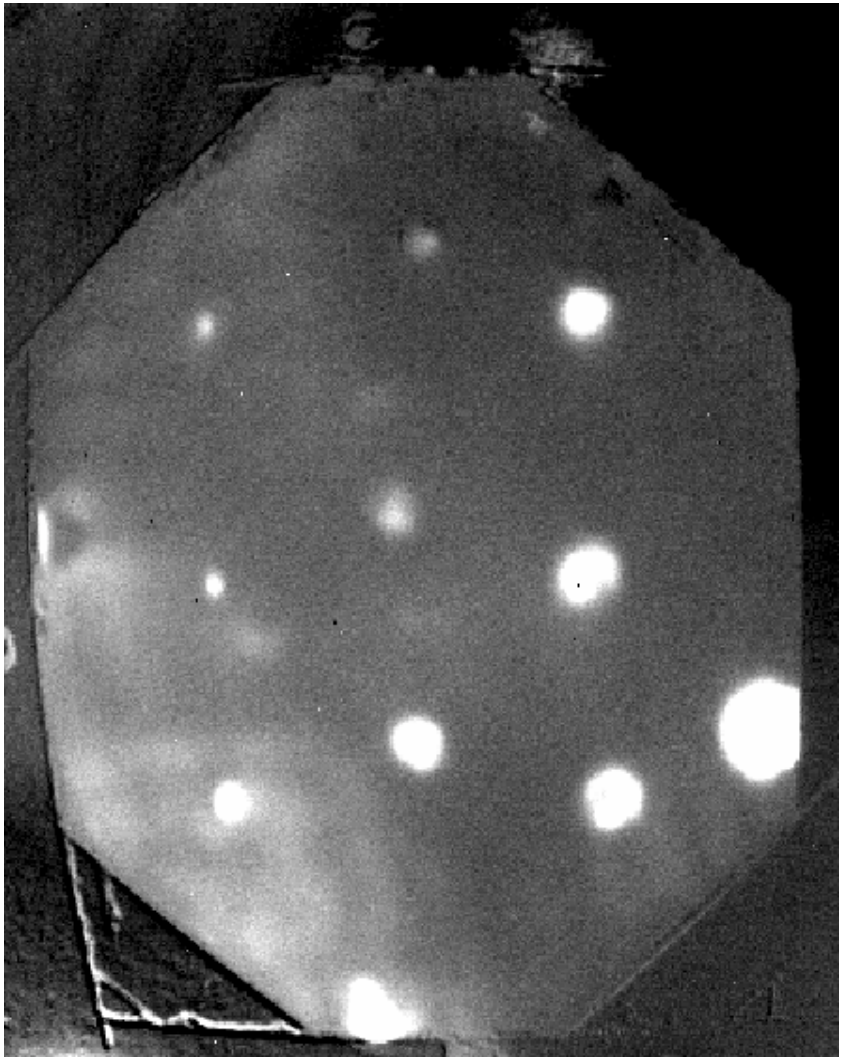
boronpatch2.avi

Boron Fiber Reinforced Composite Aircraft Repair Patch (Simulated Disbonds)



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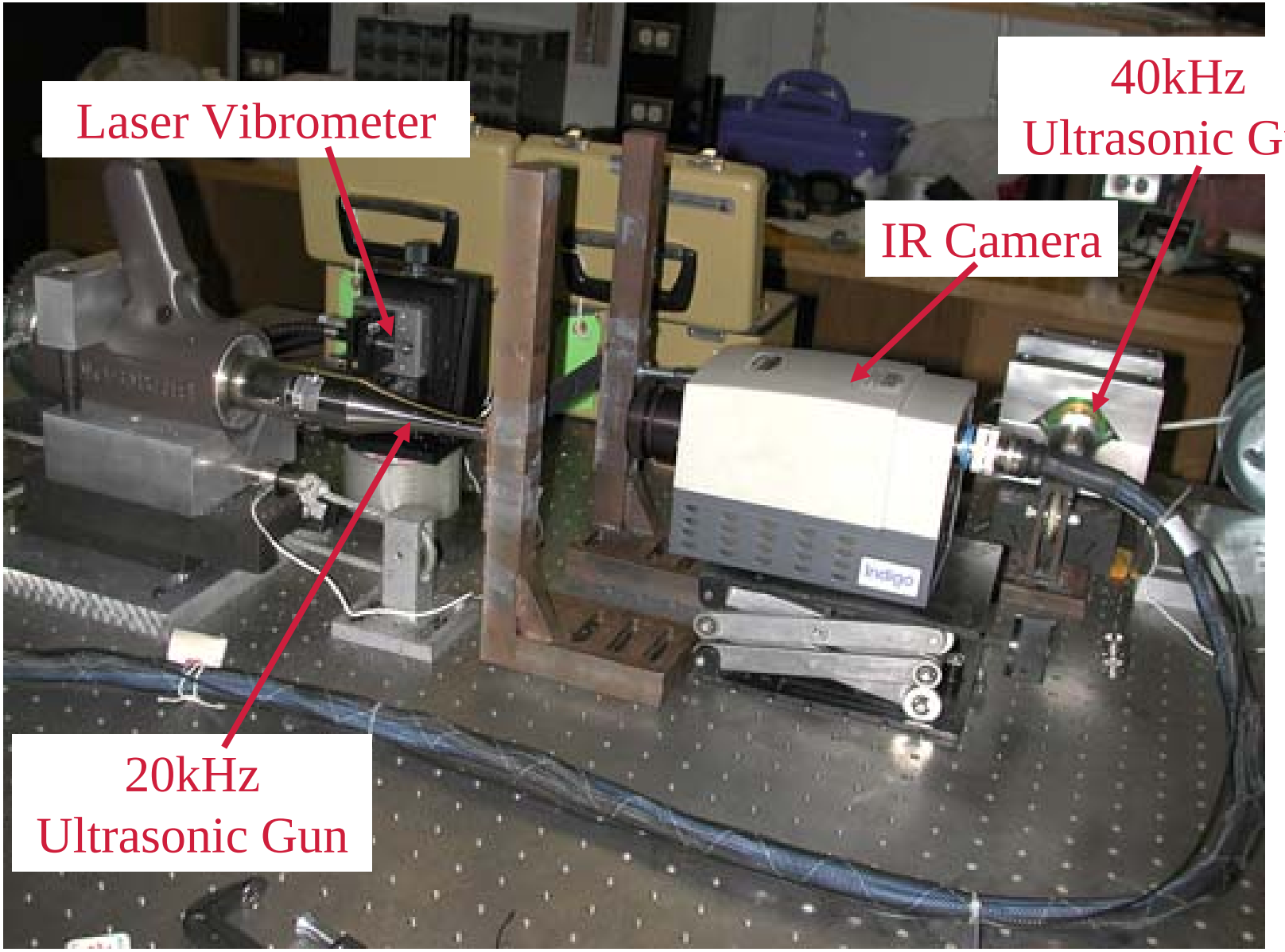

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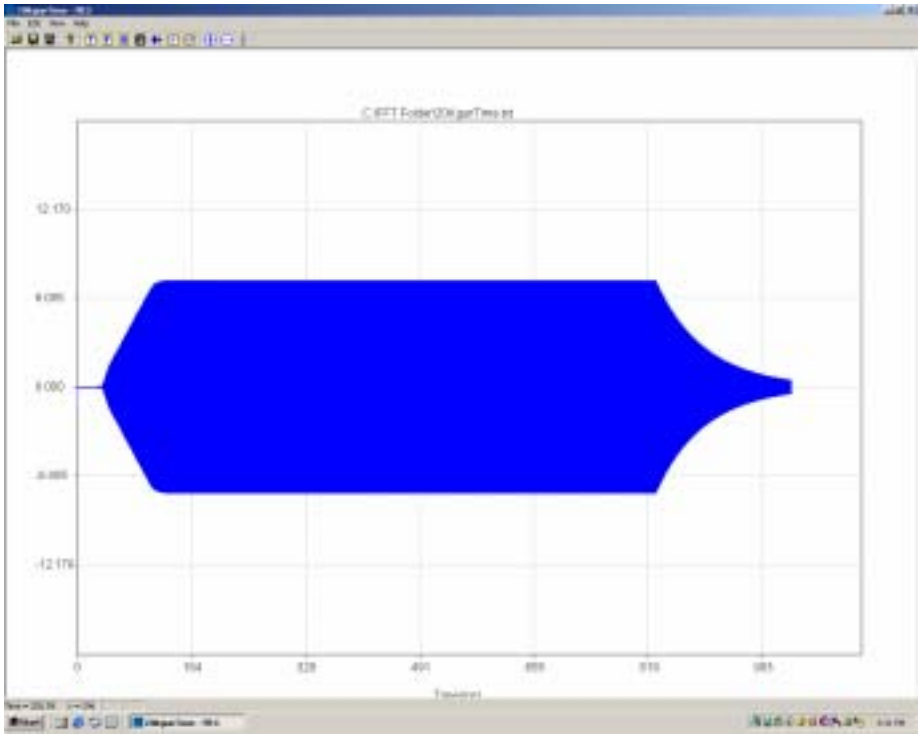
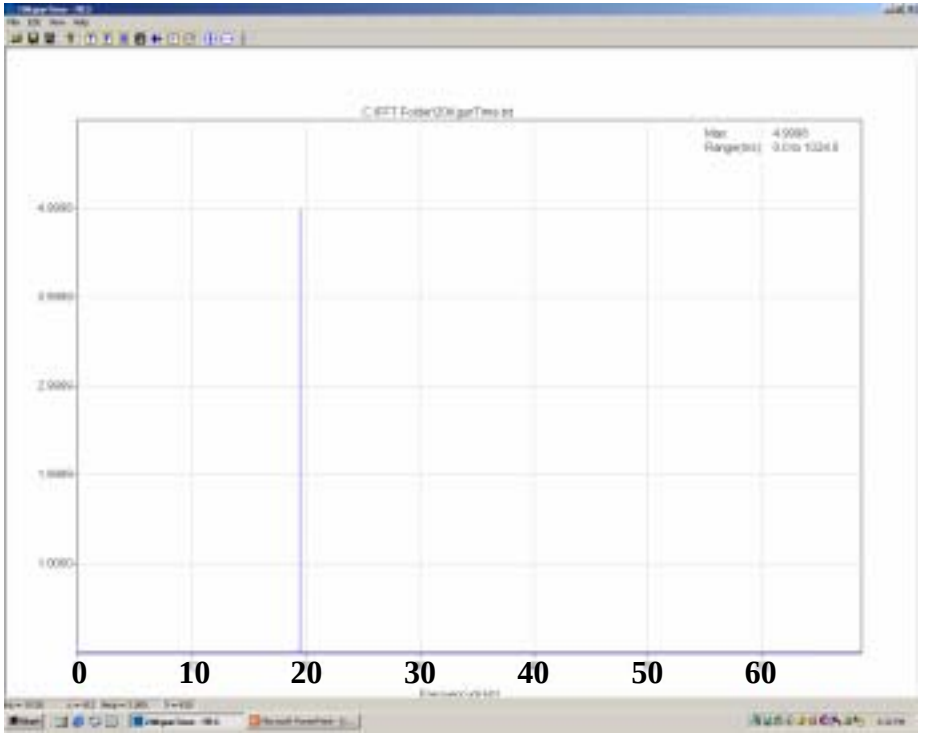


Waveform of the *Uncoupled* 20kHz Ultrasonic Transducer

FFT of the Waveform:
Pure 20kHz Frequency



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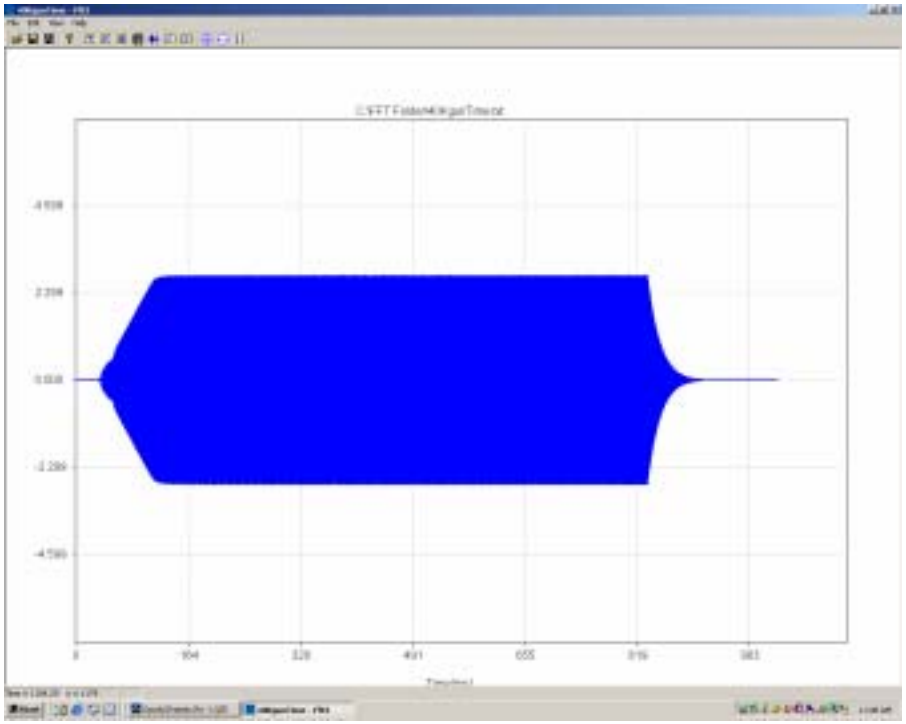
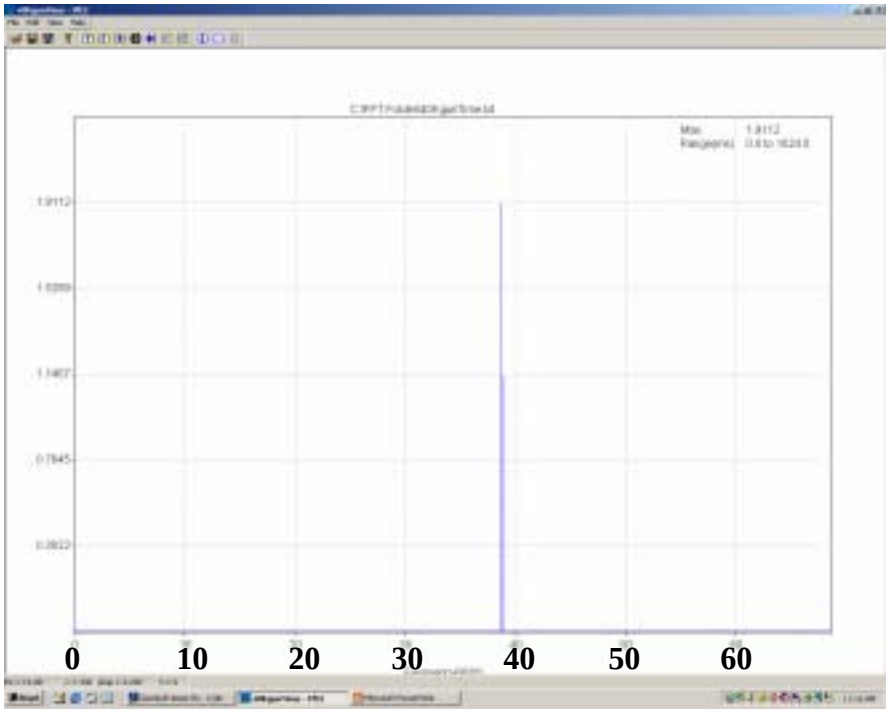


Waveform of the *Uncoupled* 40kHz Ultrasonic Transducer

FFT of the Waveform: *Pure 40kHz Frequency*



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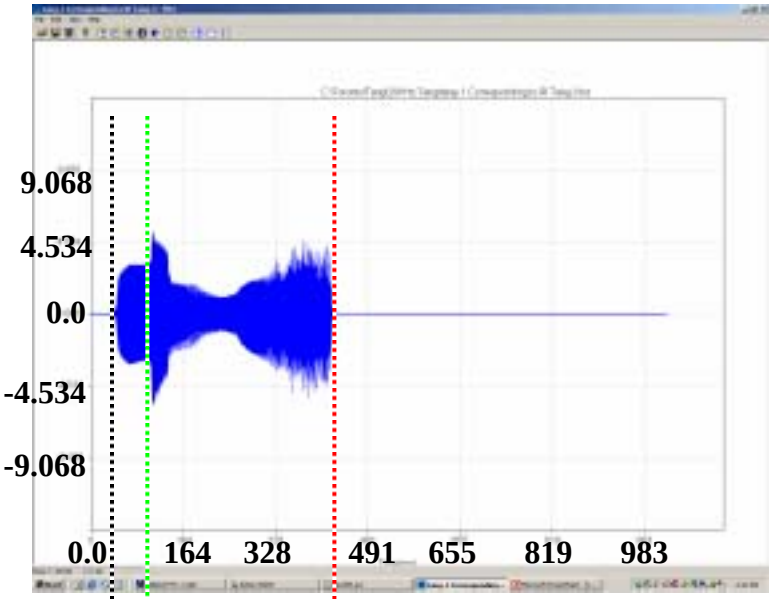
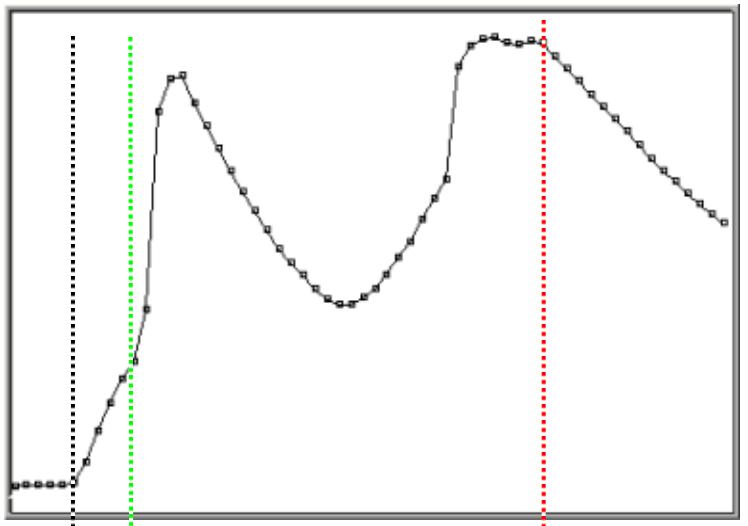
Titanium Anti-rotation Tang

Velocity Waveforms

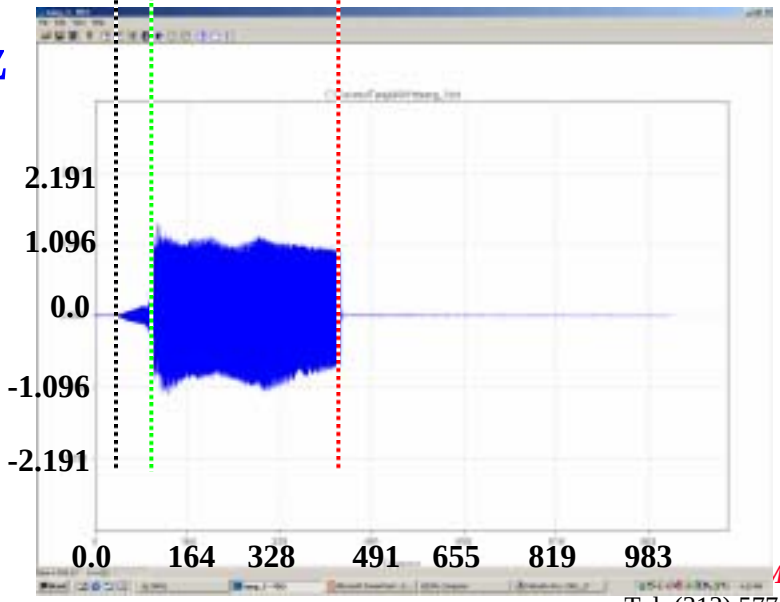
Temperature-time Curves

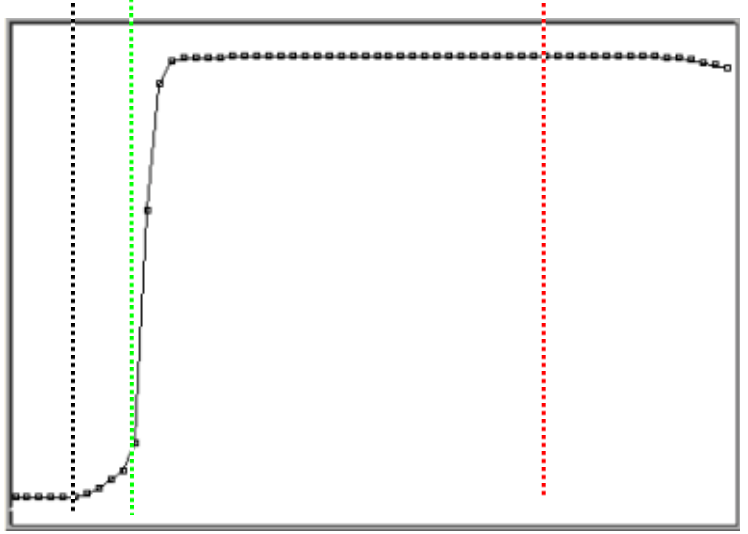
20KHz (1000W)





40KHz (800W)





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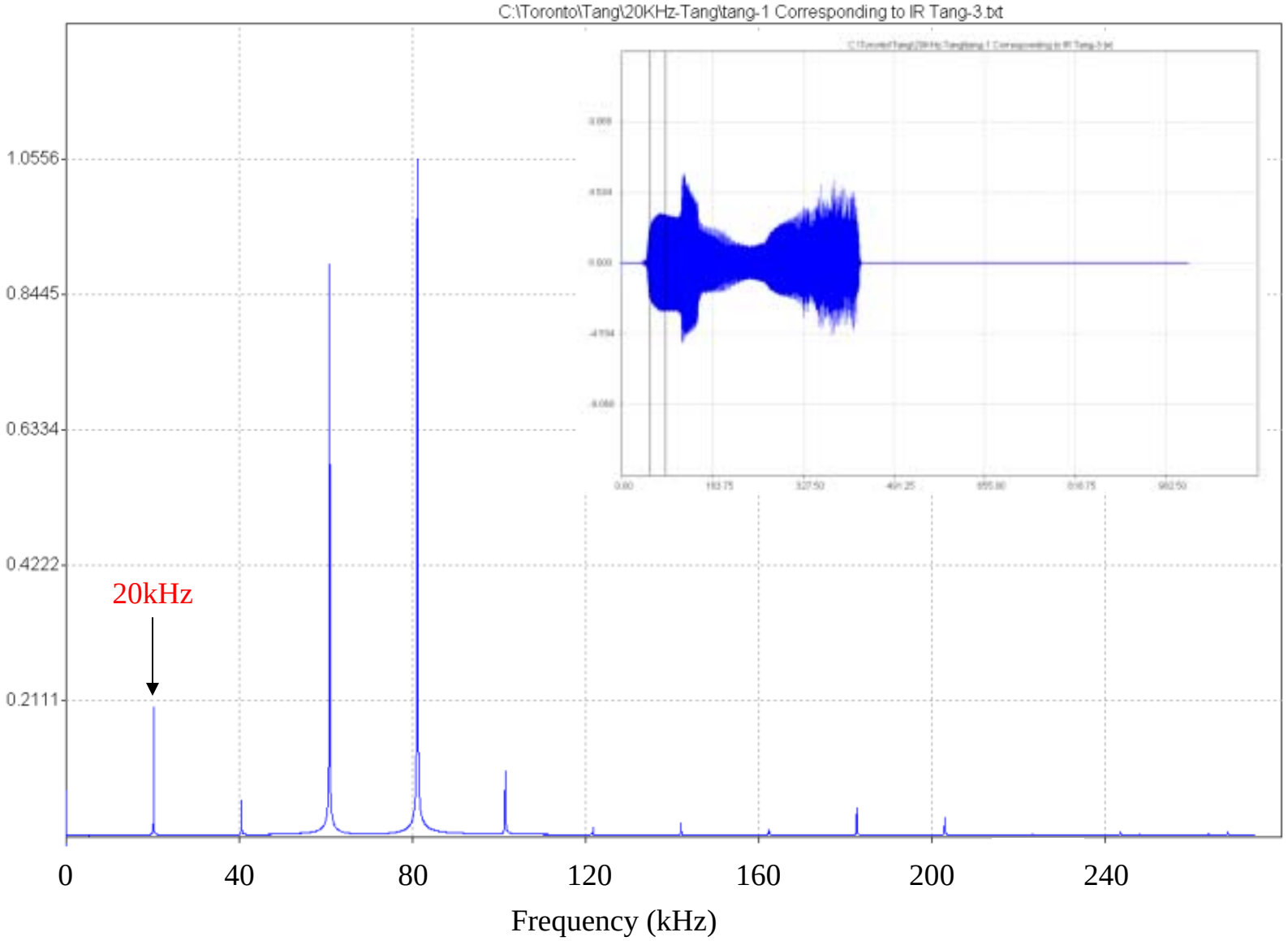

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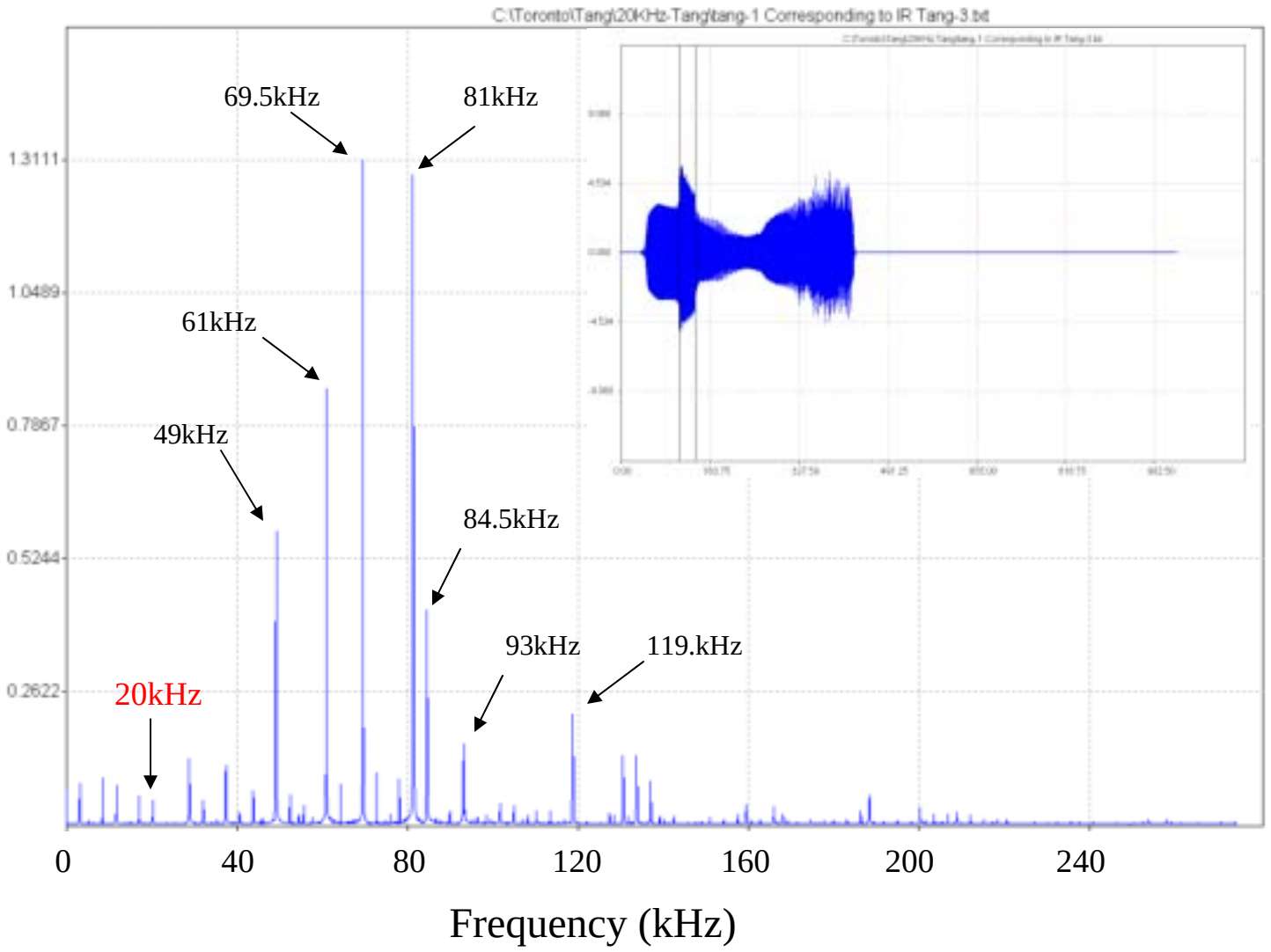

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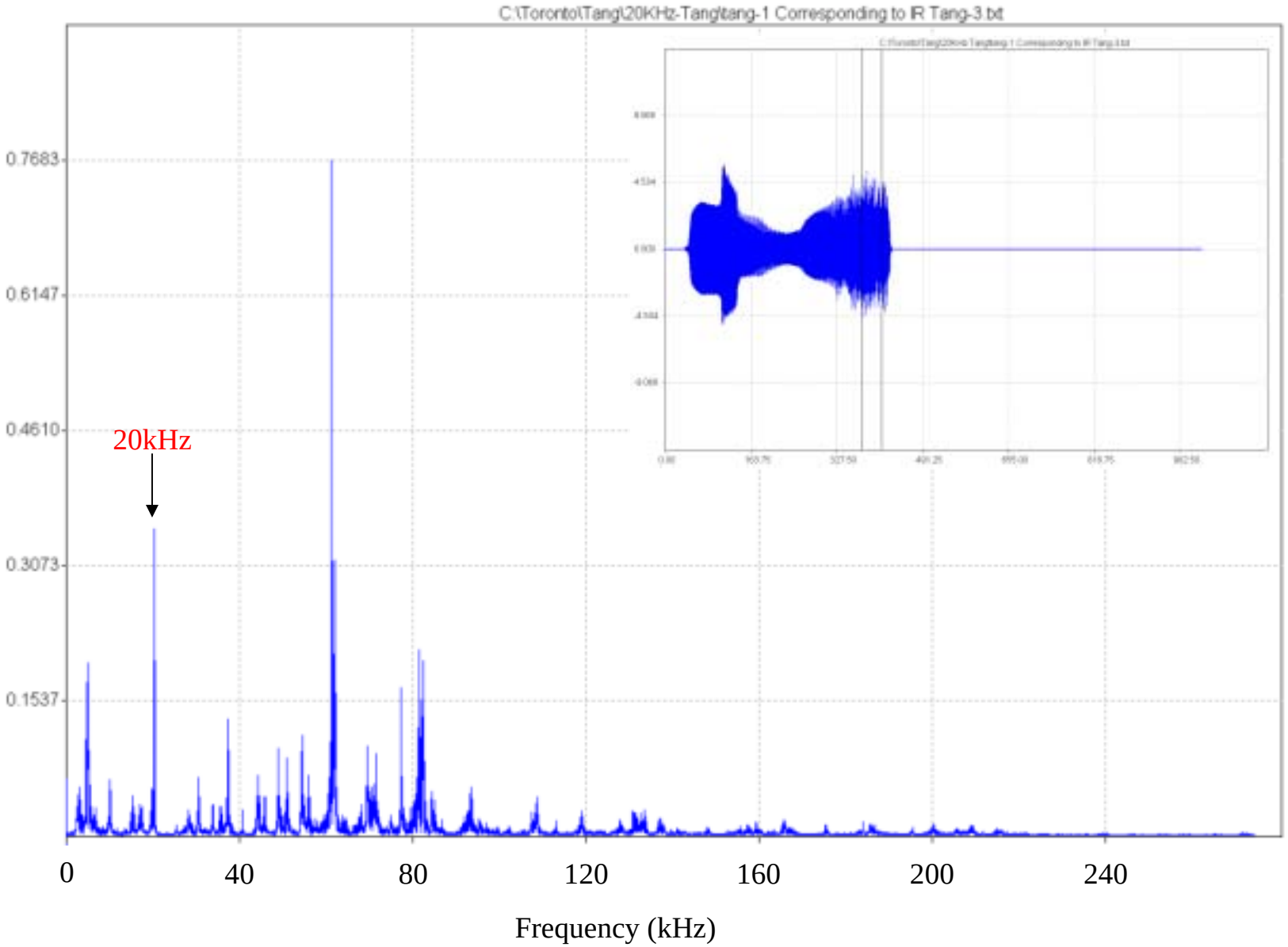

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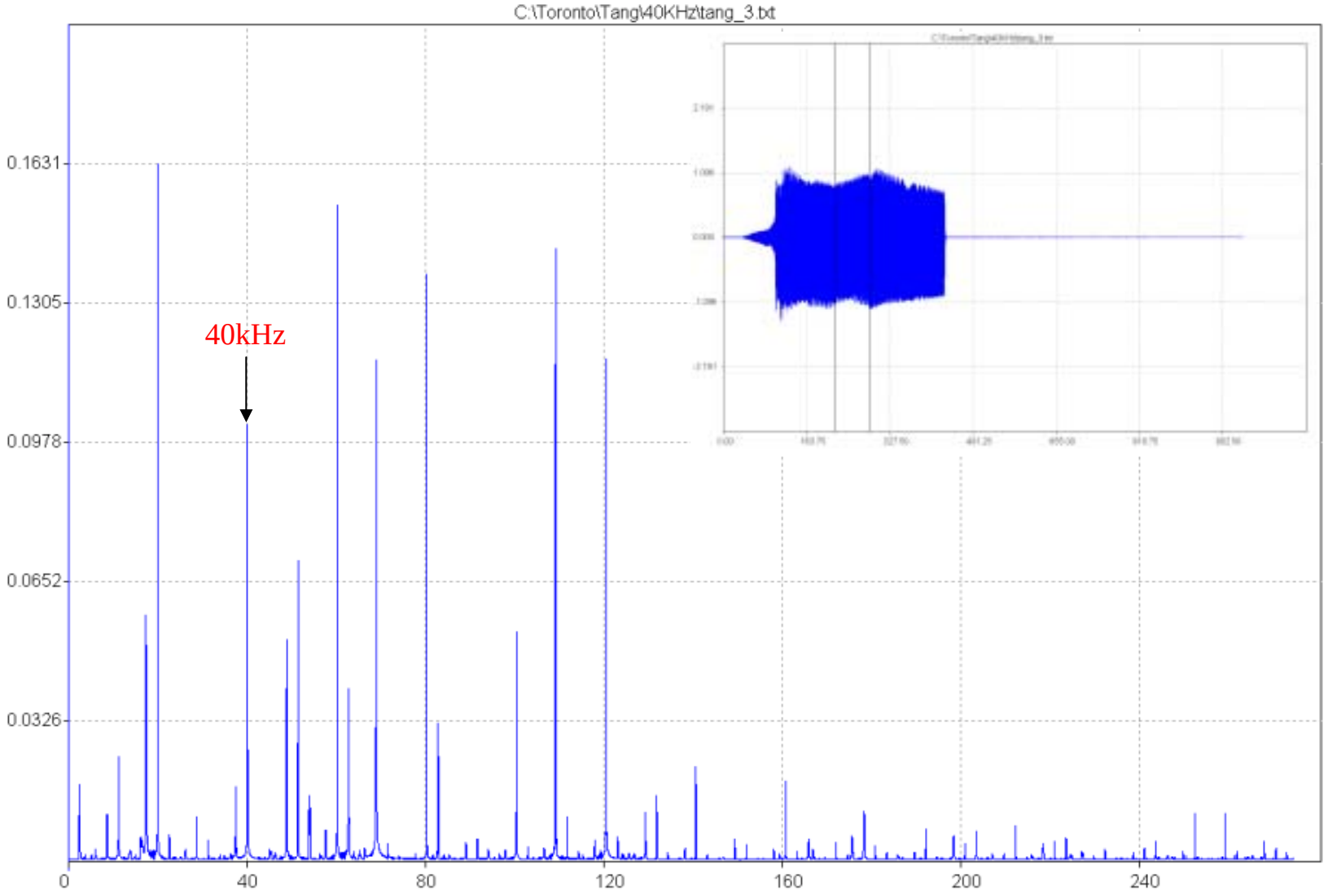

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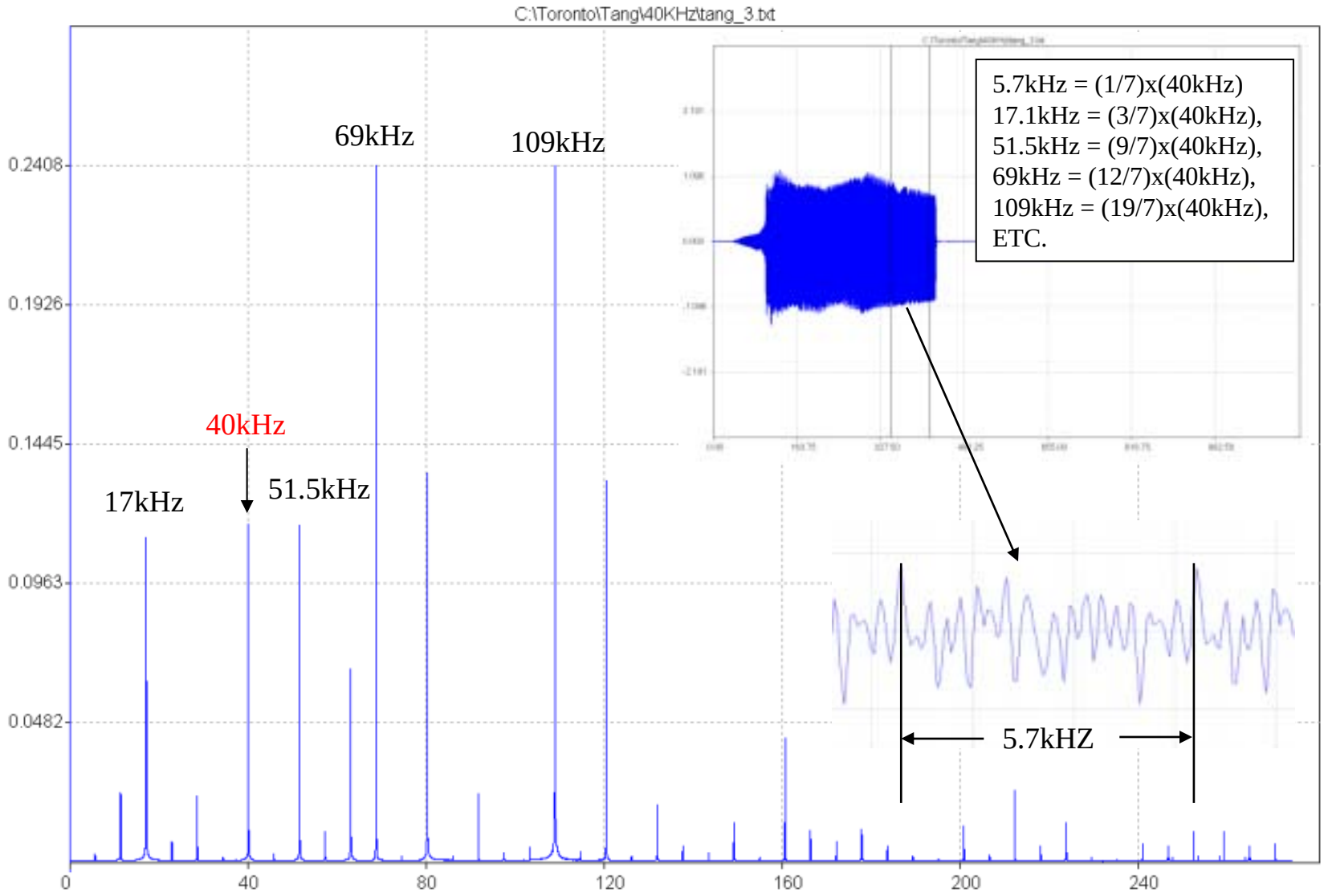
Sevenths



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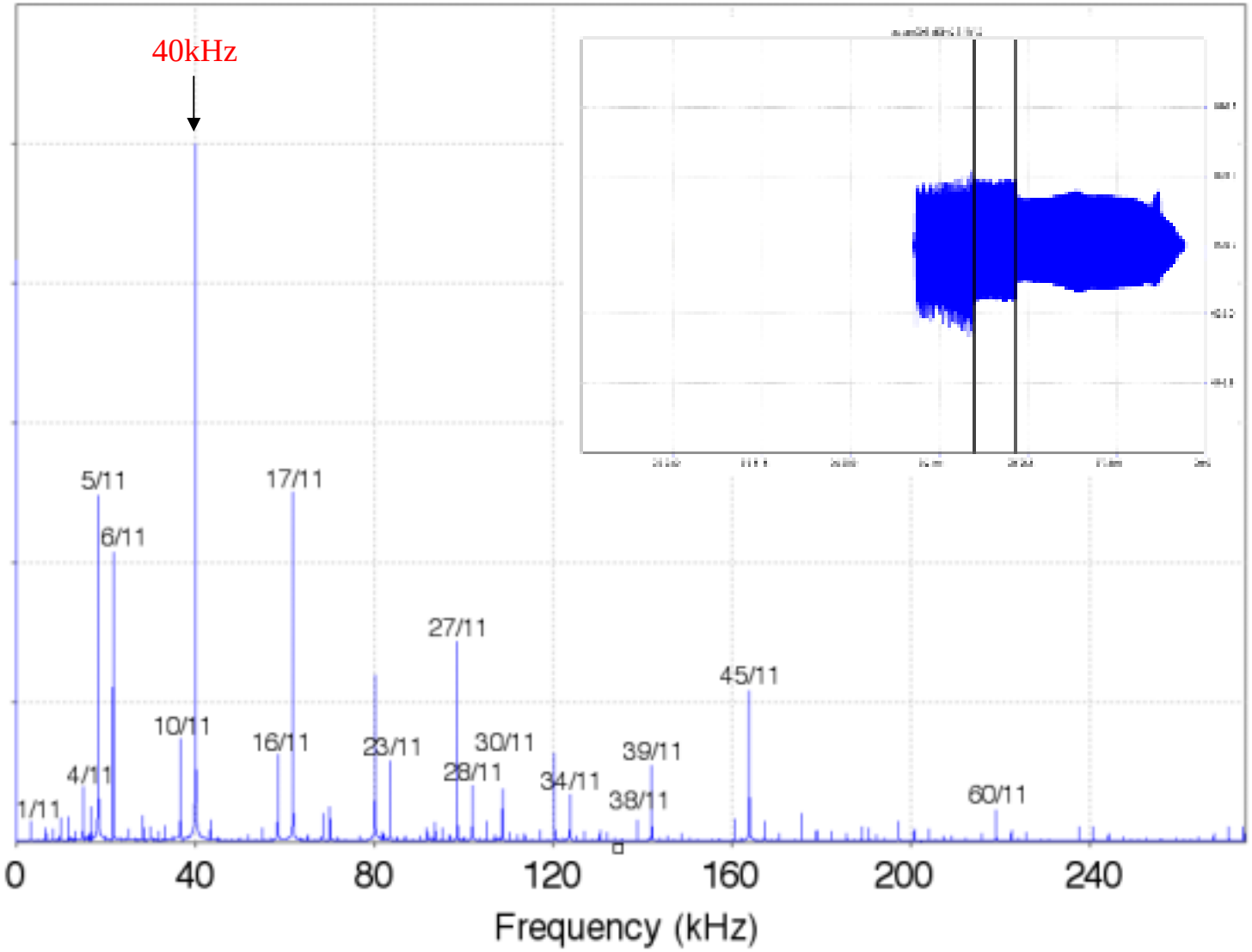
Elevenths



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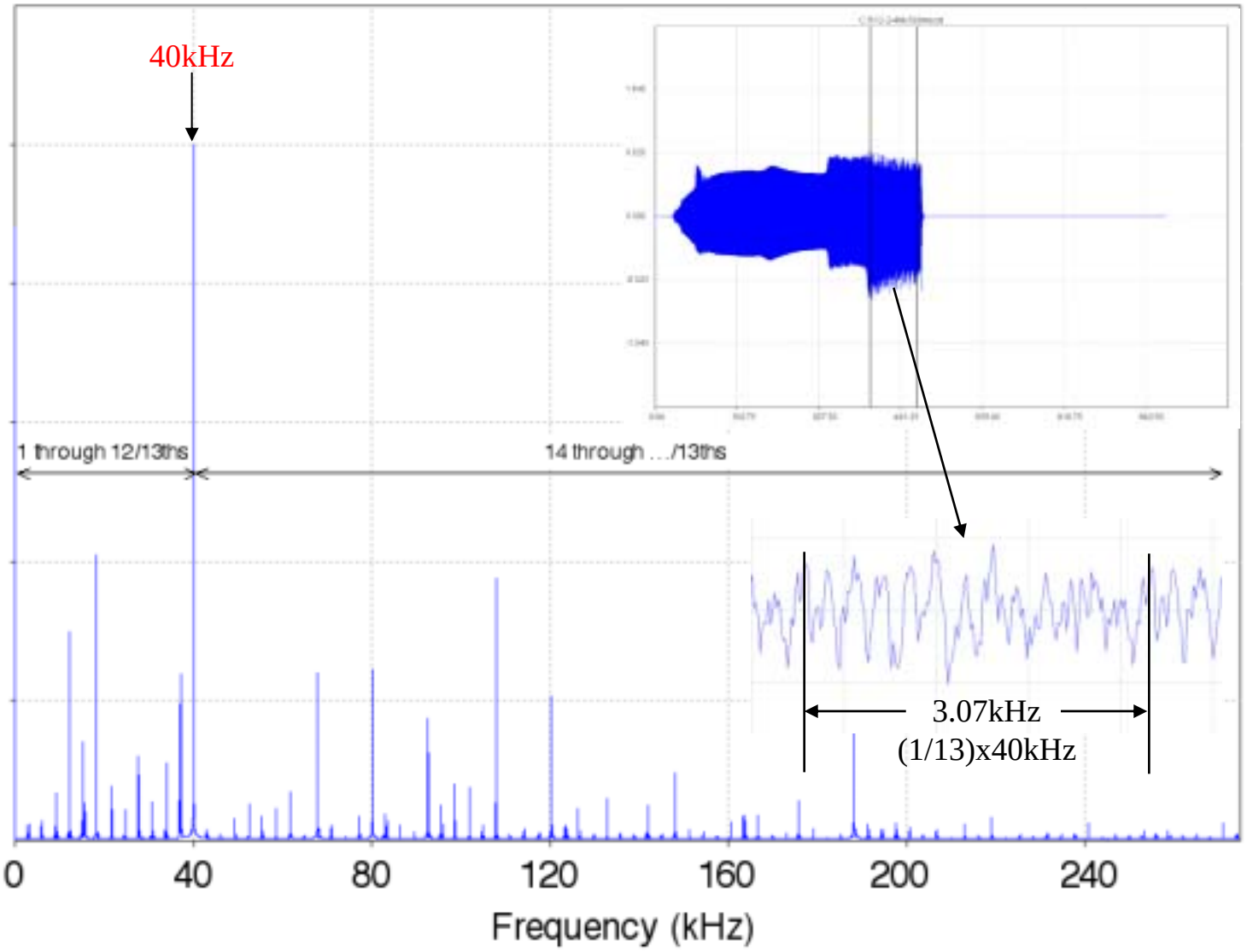

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New and Unusual Frequency Behavior:

Acoustic Chaos*

*"Acoustic Chaos and Sonic Infrared Imaging", Xiaoyan Han, Wei Li, Zhi Zeng, L.D. Favro, and R.L. Thomas, accepted for publication in *Applied Physics Letters*, tentative publication date, October 21, 2002.

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What is acoustic chaos?

Acoustic chaos, like mathematical chaos, is a state of a nonlinear system in which the future behavior of the system is so strongly dependent on the initial conditions, that it is effectively unpredictable. In our situation, the nonlinearity is introduced through the coupling of the transducer to the sample. It results in an acoustic frequency spectrum that is one or more sequences of rational fractions of the driving frequency. For reasons which are not yet understood, the chaotic behavior causes a large increase in the IR signal from the crack.

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Summary

- **Though it is a new technique, Sonic IR imaging (Sound in/IR out) is an excellent crack detection method that is sensitive, fast (< 1 second), and is applicable to wide-area inspection.**

- **The method shows good promise for inspection of engine components and other structures.**

- **The method is applicable to a variety of materials, including composites.**

- **The discovery of acoustic chaos promises to make the method even more effective.**

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